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October 5, 1959

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Rec'd 10/9/59

Dear Sir:

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This letter report summarizes the research performed under Task Order No. Z during April, May, and June, 1959. By the end of this period, the new air-film-cooled incinerator was ready to be shipped to you and the experimental feeding mechanism had been successfully demonstrated.

Air-Film-Cooled Incinerator

Experimental Work

After our meeting on April 14, the burned-out Type 304 grid was replaced with one incorporating Nichrome 5 mesh in the circular-cross-sectioned portion and Type 304 in the bottom disc.

Because of the presence of unburned and partially burned paper at the end of each test run, experimental work was aimed at obtaining complete burnout of the residue. Also, attempts were made to improve the burning rate during the normally slow period at the end of each test. Several changes in the configuration of the lower cone were made, along with changes in the operating procedure, as listed below:

(1) An annulus of perforated sheet metal was placed horizontally about 4 inches above the bottom

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junction of the two lower cones, in an attempt to allow air to circulate under the residue.

(2) The annulus was removed and four fire bricks were set on edge, in equally spaced positions, in the bottom circular "V" trough, in an attempt to introduce local turbulence instead of circular swirl.

(3) The fire bricks were removed and the four air nozzles in the lower cone of the liner were closed, in order to reduce the swirl, which was believed to cause some of the unburned paper residue to be swept up and carried unignited to the grid. Air without swirl was then supplied via 24 holes, 1/2 inch in diameter, drilled near the bottom of the lower cone of the liner.

(4) A change in operating procedure was made that involved stopping and starting the air flow at 5-minute intervals near the end of burning operation, in order to allow unburned paper on the grid to drop and become ignited by paper which was still burning at the bottom of the unit. This modified procedure was used during most of the runs made to evaluate the other changes indicated in the following.

(5) The original four nozzles in the lower cone were modified to blow four 5/8-inch-diameter jets of air in a direction reverse to the general swirl pattern of the unit. This was done in an attempt to reduce the tendency for paper to swirl and be lifted up to the grid.

(6) An obstruction in the form of an annulus of perforated sheet metal, of 36-inch OD and 24-inch ID, was installed horizontally about 12 inches below the feed opening of the liner, in an attempt to hold swirling paper down close to the burning zone.

Of the above-indicated changes, the one most effective in reducing the residue of unburned paper was the procedural modification which involved stopping and starting the flow of air near the end of the burning period; however, loose unburned paper still existed in small amounts of 10 to 20 pieces at the end of each burning period. The changes which involved reduction of air flow or swirl were accompanied by a detrimental decrease in the rate of burning. Therefore, the four original nozzles in the lower cone were restored and the 24 small holes were closed.

Final efforts to eliminate unburned residue involved the use of auxiliary heat or fuel. An electric heating coil operating at dull-red heat at the bottom of the chamber was fairly effective in reducing residue to a few small pieces. The use of about 10 lb of coke briquettes loaded at the bottom of the incinerator prior to the addition of paper also provided a source of ignition for the last remains of paper near the end

of each single-batch charge. The effect of the accumulation of ash over an extended period of burning during which the paper was added by intermittent batch loading was not determined on the performance of either the electric coil or the coke briquettes.

The unburned paper residue was most successfully eliminated by sprinkling about 1/2 pint of kerosene over the residual paper lodged in and around the electric heating element. Ignition of the kerosene filled the unit with flame and burned all of the paper resting at the bottom and on the grid.

After a discussion of these results with you during our meeting on May 12, it was decided that the use of an electric coil, coke briquettes, or kerosene would not be feasible under service conditions, and that in this unit the unburned residue could be eliminated by ultimately turning the air off and igniting the residue with a match.

With regard to the burning rate during the final period of burnout, when the burning rates normally decrease, noticeable benefit resulted when the charge was stirred with a poker at about 5-min intervals during the burnout period.

The final tests with this experimental unit, some of which were made while you were here on June 11 and 12, gave average burning rates of 275 to 300 lb per hr. In two of these tests, about 1,040 and 1,130 lb of assorted papers were charged by manual intermittent batch feeding. The residue remaining in the unit at the end of these tests was 16 and 9 lb, respectively, or 1.5 and 0.8 per cent, respectively, of the paper charged. The residue consisted mainly of loose ash, but also contained small pieces or clumps of lightly fused ash, of charred paper, and of unburned paper.

Prior to the performance of the final tests, several modifications were made to the unit in preparation for operation at your site. Figures 1 and 2 show the assembled modified unit. The alterations and additions included the following:

(1) The bottom section of the shell was rotated 180 degrees, and a new rectangular inlet duct and air damper were installed so as to fit the new blower.

(2) A new blower was obtained from the Buffalo Forge Company. The blower was identified as their No. 25, MW, Industrial Exhauster, Arrangement 4, with a 3,600-rpm, 7-1/2-hp, 220-volt, 3-phase dripproof motor and a magnetic starter.

(3) To reduce the noise level during operations, a muffler was provided at the inlet of the blower. This was a simple unit consisting essentially of a cylinder of expanded metal wrapped with Fiberglas and a wooden box lined with Fiberglas.

(4) A water manometer was provided for measurement of the static pressure in the lower plenum of the incinerator. Also, the handle of the air damper was fitted with a limiting stop, adjusted so as to give the desired air flow for the rated operation. With the air-damper handle at this stop, the static pressure in the plenum should be 4.3 inches of water.

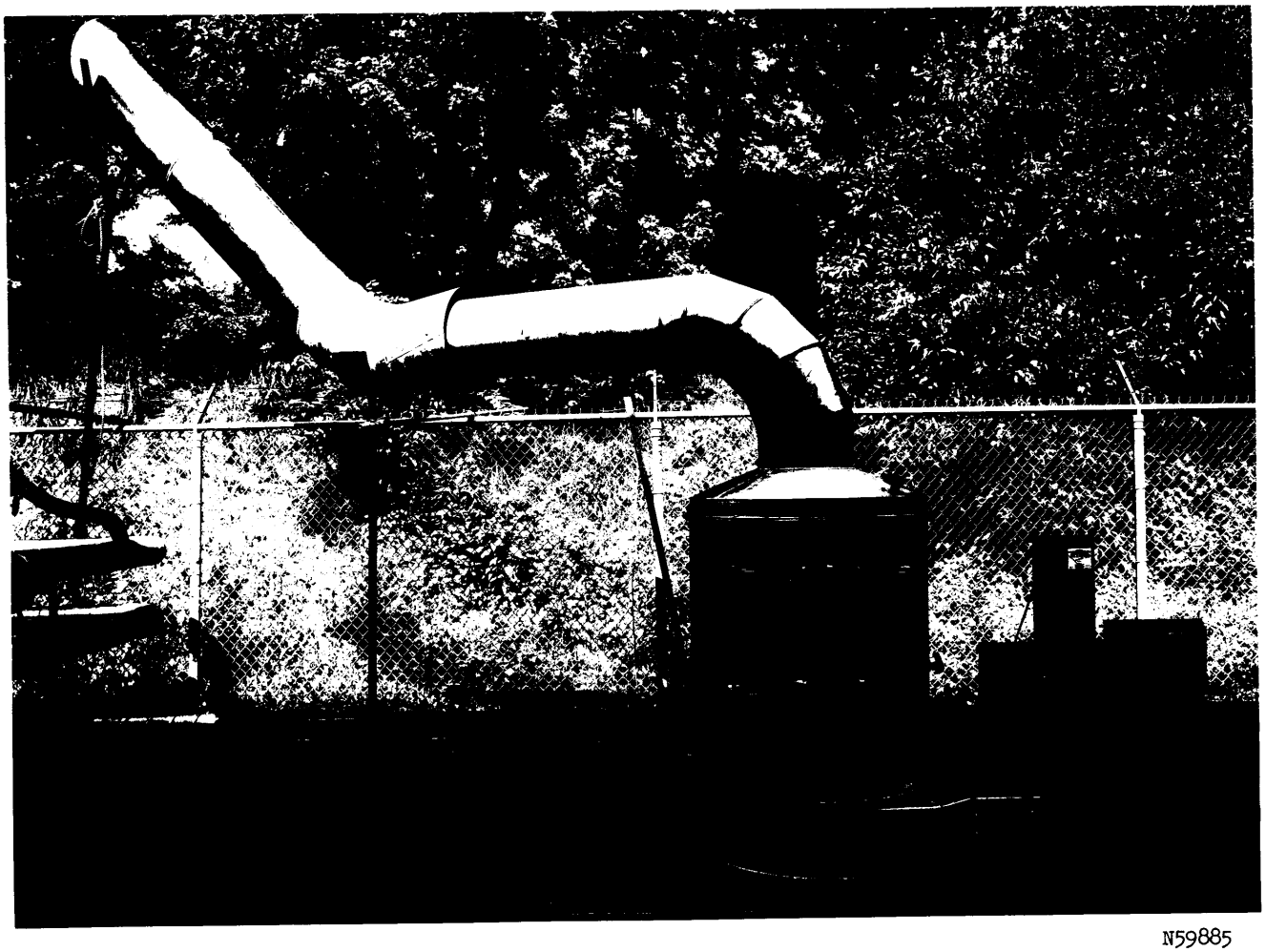

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Figure 1. Photograph of Air-Film-Cooled Incinerator

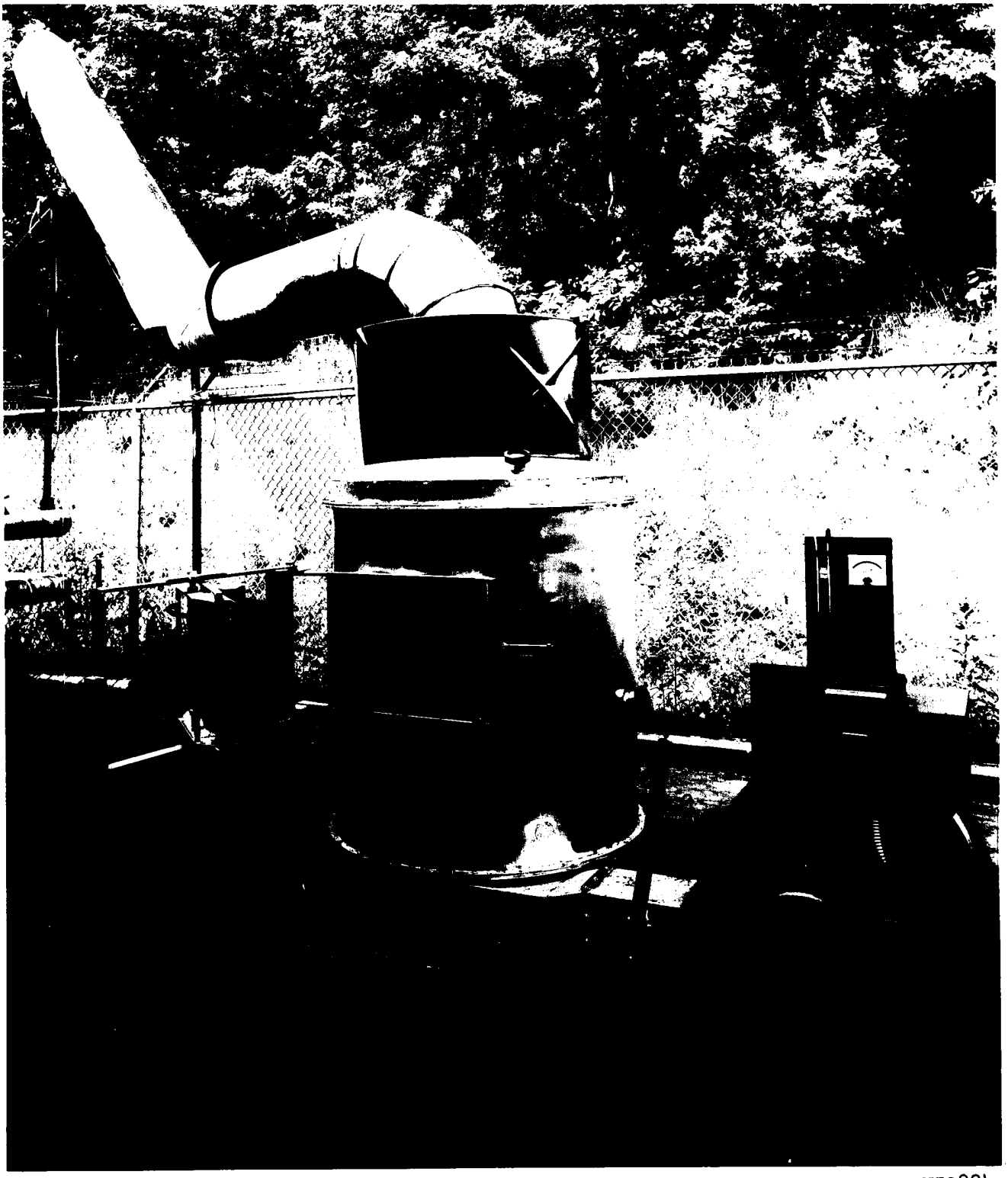

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Figure 2. Photograph of Air-Film-Cooled Incinerator

(5) Two heavy-wire Chromel-Alumel thermocouples (one as a spare) were provided for measurement of the flue-gas temperature. A Sim-Ply-Trol instrument (obtained from Assembly Products Inc.) for indicating the temperature of the thermocouple bead from 0 to 2000 F was mounted on a stand with the manometer.

(6) A hinged device for opening and closing the loading door was built and installed on the unit. In accord with your previous suggestion, the design of this device permits the loading door to be swung out so that the hot inner liner is away from the operator, for safety.

(7) A new stack was built to fit the location where the unit was to be set up. The first section of the stack including the elbow was fabricated from 16-gage Type 304 stainless steel; this was arranged so as to discharge into a bell mouth for aspiration of cooling air into an 18-inch-diameter, 16-gage mild-steel section of stack which inclined upward at an angle of about 45 degrees. A radiation shield (Figure 2) was also provided for use at the base of the stack, to shield the operator from the heat.

Outline of Suggested
Operating Procedure

During your inspection of the unit and performance of trial runs on June 11 and 12, you became familiar with the procedure for operating the unit. For the record, the operating procedure is outlined here.

For incinerating single batches of paper, a single charge of 200 lb of paper is loaded. After initial ignition of the paper, the air rate is brought up in steps of 1/4, 1/2, 3/4, and full throttle over a period of about 5 minutes, or until the fire is well established. Normally at the end of about one hour, this charge will be burned out except for a few loose pieces which accumulate on the grid and which will fall off when the blower is turned off. Burning can then be completed by igniting these with a match and operating for 1 or 2 minutes at about 1/2 air flow.

Higher rates of burning can be obtained by manual intermittent batch feeding; the level of the bed should be kept about 12 inches lower than the feed entrance, in order to get full benefit from all three horizontal rows of main air ports in the lower part of the liner. When intermittent batch feeding is utilized, the amount of the initial charge should be about 50 lb of paper, and the air-flow rate should be increased gradually during the first 5 minutes of operating. The achievement of maximum burning rates is also favored by charging small successive increments (10 to 15 lb) of paper; this size of incremental charge necessitates frequent loading, which promotes looser packing and higher burning rates.

Poking the bed during final burnout also promotes higher burning rates. This technique is particularly useful near the end of a long burning

period of several hours; if this is not done, the accumulation of ash can shield and insulate any residual "raw" paper, which then escapes ignition.

The average burning rates vary for different kinds of paper, and moisture content undoubtedly decreases the burning rate. For example, with manual intermittent batch feeding, dry newspapers were incinerated at an average rate of 700 lb per hr, while damp telephone books were burned at a rate of only about 200 lb per hr. When dry loose paper is burned, there is danger of achieving excessive flue-gas temperatures (i.e., temperatures above 2000 F) which could lead to damage of the grid. Therefore, when the flue-gas temperatures exceed 1800 F for more than a few seconds, the air throttle should be closed partially, until the temperature subsides.

At a given rate of air flow, such as full rate on the throttle, the instantaneous burning rate determines the flue-gas temperature. Burning rates were correlated with flue-gas temperatures during some of the test runs, and this correlation, in the form of a graph, has been mailed to you.

Figure 3 is a copy of the correlation of burning rate versus flue-gas temperature as read on the indicating instrument supplied with the unit. It should be noted that the degree of correlation is accurate only to within approximately ±10 per cent of the burning rate.

The unit was shipped to your site on July 1, 1959. (On July 13, a replacement "V" band for the stack flange was mailed to you. A spare grid was prepared from Nichrome 5 mesh and Type 304, and sent to you on July 24.)

Paper-Feeding Mechanism

Three major modifications were made on the loading mechanism during this period. These included:

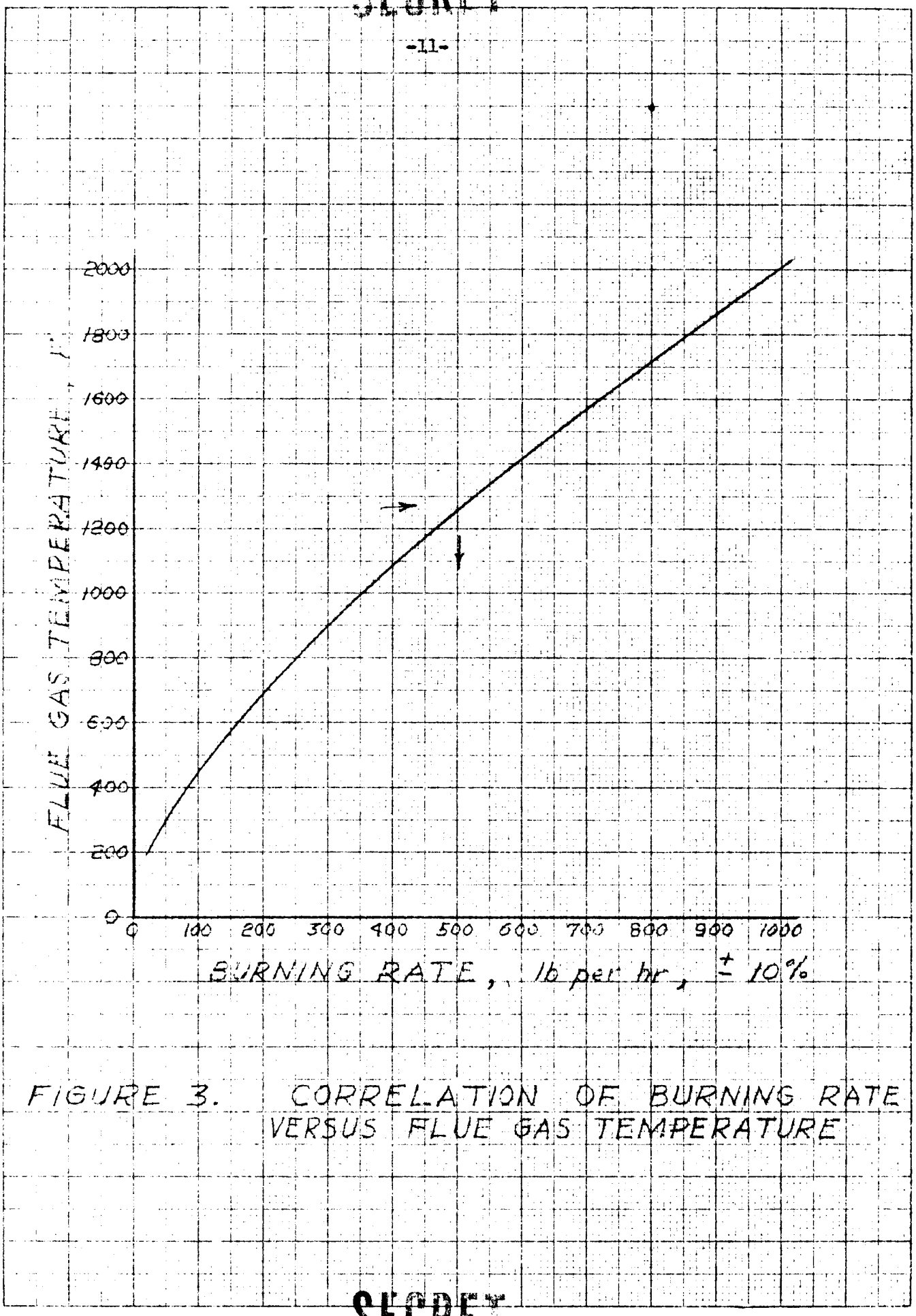

FIGURE 3. CORRELATION OF BURNING RATE VERSUS FLUE GAS TEMPERATURE

(1) Fabrication of a new fire door

(2) Fabrication and installation of an air duct on each side of the loading box, to supply sealing air to the fire door

(3) Installation of a purging chamber and suitable control valves at the front of the feeding mechanism.

The new fire door was made up of two sheets of stainless steel held 1/2 inch apart by suitable spacers. A stainless steel tube was welded between the sheets at the top of the door and a separate steel shaft was then inserted through the support bushings and fastened to the stainless steel tube. A clearance of 1/32 inch was maintained at the sides and bottom of the inner panel of the fire door when in the closed position. Thus, when air is fed into the space between the door sheets, the air escapes at a high velocity toward the fire and prevents smoke and debris from entering the loading chamber.

Two rectangular air ducts, fabricated from aluminum angle, were installed at both sides of the loading chamber in line with the fire door. Slots 3/8 inch by 10 inches long were milled in each side plate of the loading box to permit air to enter the air space in the fire door.

A purging chamber, fabricated from sheet metal, was installed at the loading end of the feeding mechanism. Air from the main blower enters this chamber through a quick-operating sliding-gate valve. The ram face was perforated with 1-inch-diameter holes to permit the purging air to flow through and around the ram on the return stroke.

Three test runs were made after the feeding mechanism was installed on the refractory-lined incinerator. Minor mechanical difficulties were encountered with the fire door in the first two tests. These difficulties, which prevented the door from closing completely and sealing the loading chamber, were corrected and all of the moving parts worked satisfactorily in the final test.

During the final test of the loading mechanism, loose sheets of paper, crumbled paper, and packs of paper were loaded into the incinerator. When the normal air flow was maintained to the incinerator, the amount of air required to seal the fire door was such that the air flow into the loading chamber during the loading of small amounts of paper caused loose sheets to blow out of the chamber. This difficulty was not encountered in the loading and delivery of paper in batches of approximately 5 lb or over. When the air flow to the incinerator was reduced to the minimum, the amount of air required to seal the fire door was small enough to allow small amounts of loose paper to be placed satisfactorily in the loading chamber. Although a choice of loading conditions will eventually have to be made, it is believed that the air-sealing function was demonstrated satisfactorily. In addition, the purging function of this mechanism, as described in the previous report, (dated June 11, 1959) was considered to be satisfactory. Thus, the present unit is ready to be checked out on the air-film-cooled incinerator, as soon as the second unit has been prepared (under the next contractual extension).

A summary report will be submitted in the near future that describes the effort performed thus far under Task Order No. Z.

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The total appropriation on this Task Order was $65,673. As of July 1, 1959, the unexpended balance was approximately $30.

Sincerely,

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